LAKE STATES FOREST EXPERIMENT STATION

REPORT TO THE ADVISORY COMMITTEE

FOR 1927

Progress in Forestry During 1927.

The forest problems in the region received a great deal of public attention during the year, and distinct progress has been made in their solution. Since the work of the Station and the progress of forestry in the region are closely interwoven, it may not be out of place to comment briefly on the trend of forest development in the States of Wisconsin, Michigan, and Minnesota during the past year.

Wisconsin

Two legislative measures marked the progress of forestry in the State, (1) the passage of a forest tax law, and (2) the reorganization of the Conservation Commission. The Wisconsin tax law, although the newest legislative act in its field has shown more vitality than similar laws in the other two States, and some 65,000 acres have been registered under the law with the promise that this area will be increased further within the coming year.

The reorganization of the Conservation Board resulted in an energetic and intelligent revision of the entire field of forest conservation in the State. It developed responsibilities and a constructive program with regard to fire protection, planting, and research.

One of the first acts of the Conservation Commission was popularizing the new forest tax law and interesting the timber owners in its advantages. The most significant provision in the new law is the inclusion of land selectively logged as coming under the operation of the law. This, probably more than anything else, is responsible for the immediate response of private timber operators to the new tax law. Another activity of the Conservation Commission was to double immediately the capacity of the State Forest Nursery and prepare plans to increase its capacity to 20,000,000 plants in 5 years.

The act enabling the Federal Government to buy land for National Forest purposes was modified by increasing the limit of such purchases to 500,000 acres, and making the boundaries of the purchase areas subject to approval not only by the governor, but also the county boards.

In no other State does there exist such an interest among private timber owners in selective logging as in Wisconsin. One more company during the year has placed its holdings on a selective logging basis.

The counties were empowered to establish county forest reserves by acquisition of land by tax deed or otherwise.

The taking of an inventory was started last year by the Department of Agriculture of the State, beginning with a survey of Bayfield County, and this work is to be greatly expanded in the coming few years. Not only the State but individual counties, like Marinette County, in Wisconsin have actually undertaken upon their own initiative a survey of land and timber resources with the ultimate view of creating zones for agricultural and forest development.

The total number of forest fire districts has been increased to eight and the entire fire protection organization strengthened. The number of fires reported during the year was 229, and the area burned over reduced to 59 acres per fire. The total acreage burned over was 12,193 and the damage about $9,450. The area under protection is now 8,575,000 acres, which is only half of the area in need of protection. The number of fires of unknown origin is still too large (88 fires out of 229).

Michigan

Michigan has made further progress in improving its fire protective organization by creating a position of "Chief Fire Warden", and instilling a better esprit de corps among its field personnel.

The status of tax delinquent lands and their passage to the State for forestry purposes is now clearly defined. A law was passed providing for slash disposal on strips of land along public highways and right of ways. The area of State Forests has been increased. The game refuges have been organized on a scientific basis and their number increased. The forest tax law is evidently in need of modification and improvement before it becomes a more important factor than it is now in solving the cut-over land problem. The land economic survey has been continued with energy and effectiveness. Maps for five counties are already available. Forest education at the University of Michigan has been reorganized and expanded to include the larger field of conservation.

Minnesota

In Minnesota the year was marked by a number of legislative acts, such as the passage of a forest tax law, the establishment of a legislative forest interim committee to study and investigate the forest problems of the State and make recommendations at the next session of the legislature, the setting aside of the State forest lands within the Minnesota and Superior National Forests as State Forests, and providing for examination and classification of all State forest lands for forest purposes.

Although the forest tax law was put into effect over a year ago, the response to it has been almost negligible. It will have to be further revised before it can become an effective measure in rebuilding the cut-over land.

No progress has been made during the past year in providing an ample and cheap supply of seedlings for reforestation purposes. This still remains an unsolved problem in Minnesota.

The Forest Interim Committee, through the intelligent and energetic chairmanship of Lieutenant Governor Nolan, made an extensive study of the forest problem, held hearings, and is drafting recommendations to the State Legislature. Out of these recommendations, there may emerge a better handling of the remaining State forest lands, and a broader forest policy for the State.

Results of Last Year's Work

The Station during last year carried nine active major projects, as follows:

1. Fire Studies.
2. Possibilities of Aspen-Birch Lands.

3. Possibilities of Scrub Oak Lands.
4. Methods of Cutting in Northern Hardwoods.
5. Effect of Water Level in Swamps upon Forest Growth.
6. Methods of Cutting in Jack Pine.
7. Thinning in Norway and Jack Pine Stands.
8. Forest Litter Study.
9. Insect Investigations.

Investigations Completed.

Of these, three projects have now been mostly completed, namely, (1) Possibilities of Aspen-Birch Lands, (2) Possibilities of Scrub Oak Lands, and (3) Study of Forest Litter.

One phase of the fire project, the Study of Forest Fires in Minnesota, has been entirely completed and the results published in the form of a bulletin by the Forest Service of Minnesota.

1. Possibilities of Aspen Lands

The study of the possibilities of aspen lands in the northern Lake States, in cooperation with the Cloquet Forest Experiment Station of the University of Minnesota, has progressed to a point where the problem and its possible solutions take rather definite shape. The aspen type in the northern part of the region occupies one-half of the area of forest land, or about 21,000,000 acres, which is divided among the three States. The amount of aspen of merchantable size is estimated to be at least 30,000,000 cords. This amount is found on some 4,000,000 acres of the type so that there remain 17,000,000 acres of small growth, much of it well stocked which is growing at the rate of one-quarter to one-half a cord per acre per year. The amount of aspen is, therefore, increasing at the rate of from 4,000,000 to 8,000,000 cords a year. There is, therefore, a very large supply of aspen already on hand, and there promises to be a still larger supply for 30 or 40 years in the future, as the present young stands reach merchantable size.

As far as can be foreseen, only a small part of this aspen is going to be grown and used for its own sake. The present consumption in the Lake States is probably between 175,000 and 250,000 cords a year. It may increase somewhat as more of it is used for paper pulp, but even after allowing for a considerable increase in consumption, it does not appear that the amount used will be more than a small fraction (less than .1) of the amount which is being added each year by growth.

The part of the project dealing with the rot of aspen, which has been handled by Dr. Henry Schmitz of the University of Minnesota, has indicated that the rot does not increase to a point where it offsets the growth until the trees are about 60 years old. Forests of aspen which are not cut and used by the time or soon after they are 70 years old, when they have 20 per cent of rot, are likely to deteriorate rapidly and become valueless. It appears almost certain, therefore, in view of the large surplus of supply and growth over consumption that considerable areas of aspen are likely to rot before they are used.

One solution of the problem lies in finding new uses for aspen which will take care of this surplus. Another possibility lies in the conversion of the aspen to pine, spruce, or other more valuable kinds of forest. Where fires have not burned too often or too hotly, balsam fir, white pine, white and black spruce, and other

species are coming up with and under the aspen, naturally. This natural conversion, however, is taking place, on the whole, only on from 10 to 20 per cent of the area of the aspen type. Natural conversion, therefore, does not provide a full solution.

The third alternative is the reforestation of the aspen area by seeding or planting. Sowing the seed of white pine and white spruce on permanent sample plots on the Minnesota National Forest has so far proved unsuccessful as a method of reforestation. The experiments have indicated, however, that mice, squirrels, and other rodents find and consume a large part of the seed that is sowed, when it is not protected from them as it was in the experiments by wire screens, and that much better success is obtained when the leaf mold is scraped off than when the seed is sown on the undisturbed forest floor. Planting of three-year seedlings or three or four-year transplants of white pine and white spruce has been quite successful in several plantations, chiefly in Michigan and Wisconsin. The failure of most of the plantations under aspen in Minnesota was due to the destruction of the planted trees by snow-shoe rabbits during 1924 and 1925, when they overran the northern part of the State.

The aspen problem, therefore, resolves itself into one of utilization, and the other of reforestation which may be accomplished with reasonable success by planting white pine and white spruce. These two species are well adapted to the good soils on which the aspen grows. They grow well, although slowly, under the aspen stands, and will increase in growth when the aspen dies out, for the conifers are much longer lived species.

2. Possibilities of "Scrub" Oak Lands

The preliminary computations and analyses of the field data obtained in the study of the scrub oak type on the sandy lands in the central part of the Lower Peninsula of Michigan, in cooperation with the Forestry Department of the Michigan State College, has been nearly completed. The volume data for the different species of oak, namely, jack, white, black, and red oak, which occur most commonly on these lands, were worked up, and it was found that the four species do not differ sufficiently to justify the preparation of separate tables. Accordingly, the data were combined and a single table prepared showing total volume in cubic feet for trees of different diameter and height classes.

Whether the data were sufficient to formulate conclusions for the scrub oak lands in Michigan, will appear as the report is prepared during the winter and spring. In any case, the conclusions in a survey study of this character must be somewhat tentative, and it will be desirable to follow them up and confirm them by permanent sample plot studies in the type. Excellent opportunities for such plots are offered both in the State Forests and on the Michigan National Forest where large areas of the scrub oak lands occur and where parts of the type have some natural growth or plantations of pine. State Forester Schaaf has already urged the consideration of the establishment of such plots on the State Forests.

There are considerable areas of what appears to be a similar type in the sandy region of central Wisconsin. It may be that some field work should be done in this region to determine whether the conditions are the same as those in Michigan, and if the results formulated from the one locality are applicable in the other.

3. Leaf Litter Study

The field study of determining the value of forest leaf litter (dead needles),

as a factor in soil fertility and the damage incurred to the forest soil through its destruction by forest fires, has now been completed.

The second annual accumulation of litter was collected from the five plots in the fall of 1927. Analysis of the data now on hand permits the drawing of the following conclusions:

Bulk per acre per year: To give some idea of the bulk of pine needle litter as it is collected in the field, the fall of litter for a year over an acre could be stuffed into 200 full burlap bags of the ordinary 2 x 4 foot size. It would be somewhat more for pure Norway pine and a little less for pure jack pine.

Weight per acre per year: The average weight of the pine litter which falls on an acre of forest floor during a year is 2257 pounds in air-dry condition or 2100 pounds oven-dry (100° C). This is a difference of 7½ per cent between air-dry and oven-dry weights (based on o.d. wt.). It is interesting to note that the total fall of litter for all five plots in 1927 was only one per cent different from that of 1926, based on oven-dry weight. However, when treated individually, the plots show as much difference from year to year for the weight of litter accumulation as they do between plots of different species for a given year. This variation is about 15 per cent. An exception to this is the two plots in pure jack pine stands, one at Cloquet and one at Cass Lake, in that their litter accumulation for any year varies very little--the least of any of the other plots, which represent combinations of differing species.

Distribution of litter: In considering uniformity of distribution of needle litter over the forest floor, those plots laid out in three separate strips (0.0096 acres each) showed a consistent variation from year to year in the amount of litter they caught. In one case of strips 200 feet apart, the annual catch differed by 50 per cent for both 1926 and 1927, showing the importance of locating the catch strips in such a study as this, to get a representative figure of the needle fall per acre.

Seasonal distribution of the fall: Two of the plots at Cloquet were established in the middle of June, 1926. The first collection of litter from these plots was made four months later in mid-October. The second collection was made about eight months later to complete the year's collection. Yet it was found that on an oven-dry basis, the weight of litter accumulated from a Norway-jack pine stand during the fall season of four months was as great as that which fell during the remainder of the year. In the other plot, in a pure Norway pine stand, the fall four months' accumulation was almost five times as great as what followed in the remaining eight months of the year period. Thus, the period when broad-leaved trees shed their leaves is also the time when pines drop most of their annual accumulation of needles.

Absorptive capacity: A portion of Norway-jack pine litter was soaked in water for two days to get an idea of the amount of moisture it would take up. It was found, after shaking the loose water off, that this amounted to 156 per cent of its oven-dry weight. Thus, a ton of oven-dry leaf litter can hold a ton and a half of water by pure absorption. Using the average figure given above for weight of litter accumulation per acre per year, 2100 pounds oven-dry, the needle fall for a year would absorb within itself a rainfall of about 0.014 inches. It must not be concluded by this figure, however, that this is all the rainfall that a forest floor of pine litter can hold. By picking up the wet litter from the floor, all the hydrostatic water drains out due to the force of gravity, and by shaking the soaked litter before weighing, the hygroscopic and capillary water is lost, so only that water which soaks into the needles themselves is considered here. Also in considering the precipitation holding capacity of forest litter in place on the forest floor, one deals with a

number of years' accumulation of litter. So the above figure is only given to show the absorptive capacity of one year's fall of needle litter substance.

Physical composition of the litter: It is estimated that fully 95 per cent of the weight of litter from pine stands is composed of needles, the remainder being bark, cones, branches, and the lesser vegetation on the forest floor. In the 1927 collection, a number of plants had come up through the rotting burlap strips or had sent long shoots in from the edges, but the weight they contribute to the total is negligible. This included such plants as Pteris, Aster macrophylla, Maianthemum canadensis, sprouts of Corylus rostrata, Linnaea borealis, and Fragaria virginiana. The one factor not considered is the rotting of entire trees that fall down, but when one thinks of the time period elapsing before every square foot of a forest floor has been covered by a decaying tree stem, the proportion of organic material being added annually in this way is very minor.

Chemical composition of the litter: The ash content of the needle litter varied approximately from 2 to 4½ per cent of the oven-dry weight. The remaining 95½ to 98 per cent is, of course, volatile matter.

SUMMARY TABLES OF LEAF LITTER PLOTS

Amount of Leaf Litter Collected During 1926 and 1927

	1926	1927
	Pounds per acre (oven-dry)	
Plot I (Cloquet) Norway-jack pine	2000	2013
Plot II (Cloquet) Pure Norway pine	2101	2464
Plot III (Cloquet) Pure jack pine	2319	1987
Plot IV (Cass Lake) Norway-white pine	1798	2189
Plot V (Cass Lake) Pure jack pine	2313	1860

Analysis of Leaf Litter Collected in 1926 (Per Acre Basis)

Com-ponents	Plot I		Plot II		Plot III		Plot IV		Plot V	
	Lbs.	Per cent	Lbs.	Per cent	Lbs.	Per cent	Lbs.	Per cent	Lbs.	Per cent
Ash	52.2	2.61	41.0	1.95	69.8	3.01	75.5	4.20	105.0	4.54
N	14.8	0.74	8.0	0.38	16.5	0.71	14.1	0.78	16.5	0.71
CaO	13.0	0.65	9.9	0.47	15.7	0.68	20.8	1.16	21.0	0.91
P_2O_5	2.6	0.13	2.1	0.10	3.5	0.15	3.4	0.19	3.1	0.13
K_2O	2.6	0.13	3.2	0.15	3.0	0.13	3.4	0.19	3.5	0.15
SO_3	5.6	0.28	5.7	0.27	6.7	0.29	5.9	0.33	6.7	0.29

For the chemical constituents, the amount of N, CaO, P_2O_5, K_2O, and SO_3, in per cent of oven-dry weight was determined. From the table it will be seen that the N and the CaO per cents were the ones which varied most among the plots. Plot II in pure Norway pine is unusual in that 98.05 per cent of the oven-dry weight is volatile and it only has about one-half as much nitrogen as the other plots.

In comparing the two pure jack pine plots, III and V, one finds almost one-third again as much ash in V as in Plot III, yet the total weight of litter is the same and the other chemicals are much alike.

On the strength of the chemical composition of the leaf litter plots as given in the table, Dr. Alway, the head of the Division of Soils of the University of Minnesota, has computed that the nitrogen content alone in the leaf litter amounts on the average to 15 pounds per acre. The soils on which the leaf litter was collected would produce, with liming, somewhat better than two tons of alfalfa hay per acre per year. This would carry about 100 pounds of nitrogen. It is evident, therefore, that one-sixth to one-eighth of an acre of alfalfa collects from the air just about as much nitrogen as is contained in one acre of leaf litter. This is, of course, the accumulation of leaf litter for only one year. In unburned forest, there is an accumulation of 3 or 4 years of litter. Therefore, fire that destroys this accumulated leaf litter robs the soil of from 45 to 60 pounds of nitrogen, replacable by from $9.00 to $13.00 worth of sodium nitrate per acre.

Final results of this work will be written up for publication during the year.

Investigations Underway.

On the following five projects, work was continued during the year: (1) Methods of Cutting in Northern Hardwoods; (2) Fire Studies; (3) Management of Swamp Forests; (4) Thinning in Norway and Jack Pine Stands; (5) Insect Investigations.

1. Methods of Cutting in Northern Hardwoods

This work was concentrated at the Upper Peninsula Forest Experiment Station, 20 miles east of Marquette, Michigan. Four schemes of cutting have been tried so far on a total of 40 acres.

(1) Selective cutting down to an approximate diameter limit of 22 inches; removing about one-third of the volume of the stand. This cutting was made during the fall of 1926, and the results were reported in last year's investigative program.

(2) Selective cutting with the aim of removing overmature, defective, and deformed trees, regardless of size, to leave the stand in a good growing condition, thereby removing about two-thirds of the merchantable volume. The volume removed corresponded to a diameter limit of about 18 inches.

(3) Cutting to a fairly rigid diameter limit of 12 inches, representing a commercial operation for sawlog material only.

(4) Clear cutting, that is, utilizing all material in trees down to 6 inches in diameter for either sawlogs, mine timbers, or chemical wood.

The last three methods of cutting were applied during the fall of 1927. Disposal of slash by piling and burning is being tried out on two of these units. Although observation and limited experiment have indicated that hardwood slash needs no special treatment where close utilization for chemical wood is practiced, the question is by no means a closed one.

A general summary of the character of the cuttings is given in the following table.

GENERAL SUMMARY

Experimental Hardwood Cuttings
Upper Peninsula Branch Station, 1926-1927

All species - per acre basis
Only trees over 5 inches d.b.h.

	22-inch Diameter Limit Cut	"Silvicultural" Cutting	12-inch Diameter Limit Cut	Clear Cutting
		Area cut over - acres		
	20	10	5	5
		Number of trees		
Original Stand	106.9	109.7	111.6	107.6
Removed (Cut)	10.4	41.2	49.6	107.6
Left	96.5	68.5	62.0	-
Per cent cut	9.7	37.6	44.3	100.0
		Basal Area - square feet		
Original Stand	107.8	121.8	126.0	134.1
Cut	26.7	65.9	99.8	134.1
Left	81.1	55.9	26.2	-
Per cent cut	24.8	54.1	79.2	100.0
		Average d.b.h. - inches		
Original Stand	13.6	14.3	14.4	15.1
Remaining Stand	12.4	12.2	9.2	-
		Volume - board feet		
		(Net Scribner scale in trees over 12" d.b.h.)		
Original Stand	6350	8000	7903	10194
Cut	2250	5035	7408	10194
Left	4100	2965	495	-
Per cent cut	35.4	63.0	93.7	100.0

No figures are yet available as to the value of the timber removed under the last three methods of cutting.

In addition to the actual logging operations, permanent sample plots were established on the area cut over in the fall of 1926. A study of the composition, rate of growth and deterioration, and the changes which take place in a virgin forest was also initiated. This is to serve as a background for all the methods of cutting that will be tried on the experimental forest. In the past all our studies were concerned with cut-over land or second growth. This is the first study of its kind which tries to find out what is taking place in the virgin forest.

A 2-acre permanent sample plot was established in 1927 on the uncut area belonging to the Station. On this plot all trees over 1½ inches in diameter at 4½ feet from the ground were measured and tagged, and eight .01-acre reproduction plots were laid out on which all of the smaller trees were tallied and the character of the ground cover noted.

A careful analysis was made of the distribution of the different sizes of trees. This analysis has been worked up in the form of a separate paper which may be published within the year.

2. Fire Studies

With the completion of the report on "Forest Fires in Minnesota", the analysis of Michigan fire statistics is being pushed to completion. As was anticipated, the data already compiled were inconclusive, and it has been necessary to compile the material that has since become available in order to arrive at satisfactorily safe conclusions. This work is now under way, and it is hoped that the Michigan report can be completed and published during the coming year.

The cooperative work between the Weather Bureau and the Forest Service in fire weather forecasting was extended during the year over northern Minnesota, Upper Peninsula of Michigan, and northern Wisconsin. The value of this service is apparently appreciated by the State forest services, but because of a favorable fire year the forecasting was not put to a severe test.

3. Management of Swamp Forests--Effect of Water Level in Swamps upon Forest Growth

Examples of favorable reaction of tree growth to swamp drainage come chiefly from Europe. In order to show that trees respond to drainage in this country as well, and to build up the number of actual figures taken from American swamps, a study was made of areas drained for agricultural purposes. A number of swamps were ditched and remained uncleared of their forest growth, when it was found that farming on such land was an expensive undertaking.

An example of this ditching and abandonment of a swamp intended for agriculture is the Williams Swamp in Minnesota, lying 15 miles northwest of Duluth. It was drained in 1918 by parallel ditches and laterals about 600 feet apart. The main ditches were from 4 to 5 feet deep and 3 feet wide at the bottom, with the laterals somewhat smaller.

This drainage had reduced the water level from close to the surface, where it stood most of the year, down to 2 or 3 feet beneath. Being a Sphagnum-covered swamp bearing an open stand of stunted tamarack and black spruce, the precipitation was easily absorbed and held by the moss, preventing the occurrence of bone-dry conditions. Yet in this particular instance, the form of the swamp, the type of the peat, and the position of the ditches were so in accordance with the ameliorative need of the trees, that marked increase in growth occurred the year after ditching.

Ten trees were cut and analyzed to determine the growth before and after drainage. The results show that both tamarack and black spruce responded to the improved growing conditions, even though growing on peat varying in depth from 7 to 15 feet and from 130 to 225 feet from the drainage ditch. An outstanding example of the extreme which can be hoped for in such drainage improvement work is a certain tamarack tree which was 10 feet high and 1.13 inches in diameter at the time of drainage. Seven years later it had more than doubled its dimensions, being 20 feet high and 2.60 inches in diameter, thereby increasing its volume by over 100 per cent per year. If drainage had not occurred, the computed probable dimensions of this tree would have been only 11 feet high and 1.26 inches in diameter, a typically insignificant rate of growth for "drowned" forest trees.

The distance from this tree to the ditch was 225 feet which accentuates its phenomenal response to drainage. The other trees analyzed showed a volume increase due to drainage of 14 to 75 per cent per year. By studying such extreme cases found in drainage attempts, whether they are extremely good as in this case, or extremely bad as often happens, it is hoped to bring out some of the controlling factors.

Another instance of improved growth was found on the Northeast Experiment Farm at Grand Rapids, Minnesota. Here in 1910 a tile drainage system was laid through a peat bog to lower the water level for experimental farming. The cut for the drains was from 2 to 4 feet deep. The swamp was a typical bowl-shaped Sphagnum bog of northern Minnesota, covering 20 acres with peat 22 feet deep in the center. The scattered clumps of black spruce and tamarack were cleared from only a portion of the drained area, so that an opportunity for observations on tree growth was possible. This was done just 15 years after the tile was laid.

A typical black spruce, which was 12 feet tall and 0.80 inches in diameter in 1910 was found to be 18 feet tall, with a diameter of 2.80 inches in 1925; an increase in volume of 92 per cent. A typical tamarack which was only 2½ feet tall at the time of drainage, grew in the 15 years to a tree 24 feet tall and 3½ inches in diameter.

Such cases as found on these two areas are encouraging evidence that under certain conditions swamp trees will substantially increase their growth with drainage. However, the ubiquitous drainage attempt, both in this country and Europe, which has failed to accelerate the tree growth, incites one to caution when studying this problem.

The other phase of the swamp experiment undertaken by the Station, that of actual drainage under controlled conditions, offers some interesting data this year.

Analysis of the swamp water-level readings taken during the year has brought out some sharp differences in the reaction of the two experimental swamps to drainage. The physical conditions involved play an important part.

In the Minnesota swamp we have a good example of a bowl-shaped type of swamp, supporting a scattered stand of black spruce. It is about 1500 feet long, 500 feet wide, and 13 feet at its deepest point. The peat is chiefly an open, undecomposed bed of Sphagnum. So-called "girdle" or protection ditches were put around the edge, and a main ditch carries the water through the rim and out to where the terrain slopes away--a distance of about 75 feet beyond the rim. Continuous well readings, before and after drainage, show that the water level has been lowered from its position close to the surface, where it stood most of the year, to a foot below the surface. Since black spruce is a very shallow-rooted species, we hope that this change in water level will be sufficient to show marked improvement in the rate of growth within the next year or two. There are two gates in the ditch system by which the water level can be still further lowered if needed, or raised if the peat tends to dry out too much. In the graph showing the changed water level due to the ditching of this Minnesota swamp (Graph 1), the slight seasonal fluctuation of the water level can be followed. Even after concentrated months of rainfall, as occurred in June and August of 1927, it will be noticed that the ditches hold the water level below even the minimum level of 1926. In this experiment, the openness of the peat permits the water to pass quickly through it and into the ditches.

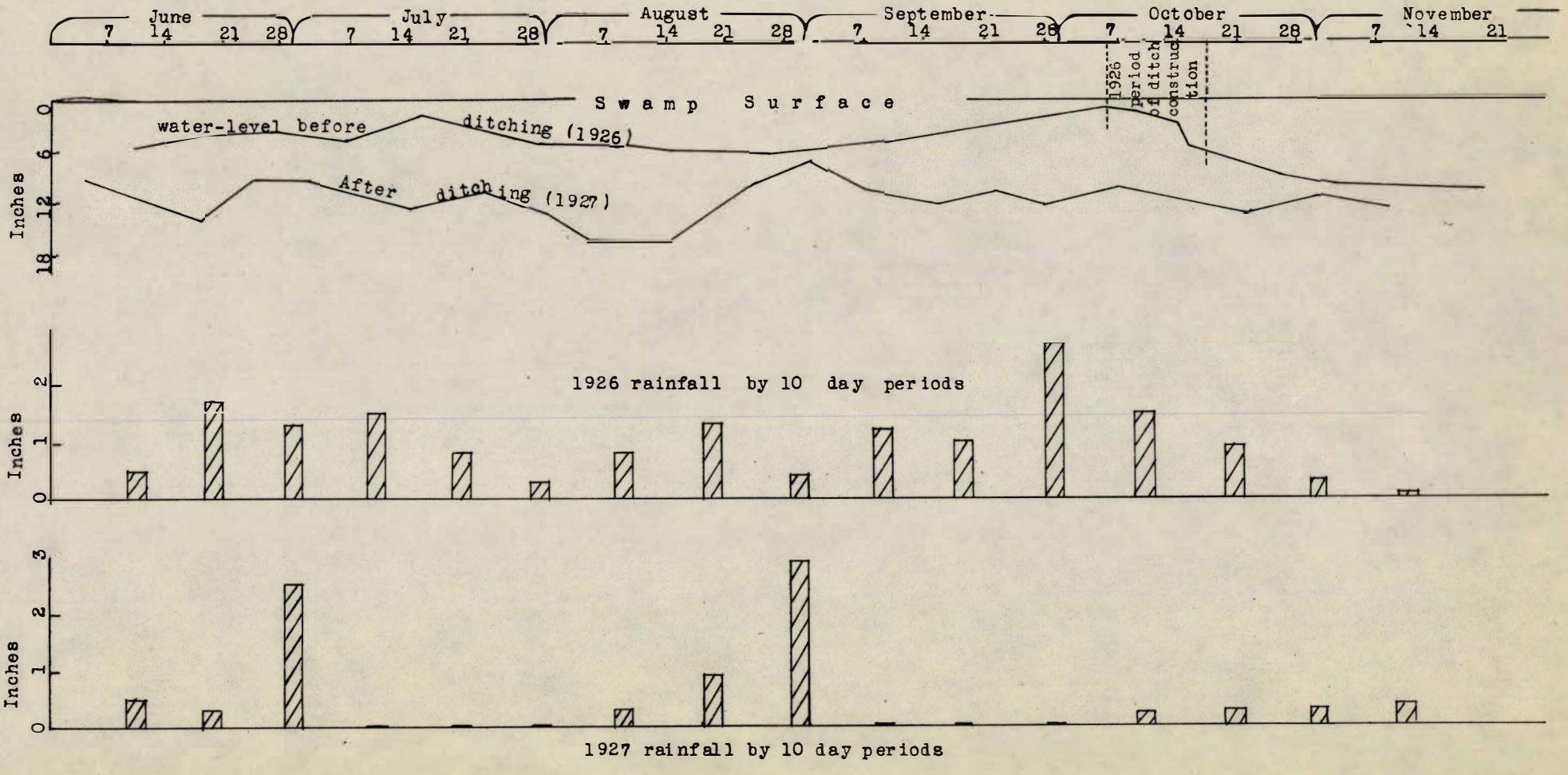
The Michigan swamp, on the other hand, is of a very different character, both in kind of peat and shape of bottom. It is a type that should respond most generously to any drainage of excess water. The soil is a well decomposed woody peat, about 3 feet deep, lying on a gradual and uniformly sloping bottom. It is covered with a rather close stand of slow-growing cedar and fir. The natural outlet seems to have

GRAPH I

SEASONAL TREND OF WATER-LEVEL IN A DITCHED

SWAMP IN MINNESOTA

1926 - 27



been cut off by the paved highway running by, but the accompanying road ditch has prevented surface water from collecting. Good results have not been obtained yet with the ditching system used.

A 10-acre portion of this swamp was selected for study, and a single ditch laid through the center in such a way that it empties into the highway drainage system. The well readings in the swamp show that this ditch has not been effective. however. It was expected that the water table would be lowered near the ditch, rising to an unchanged level some distance back on either side. But the graph of the water level 50 feet from the ditch as compared to that 250 feet back (Graph II) shows a difference of only a couple of inches, an amount of no practical significance. The seasonal variation of the water table, however, is about 2½ feet, and its comparison with that in the Minnesota swamp is very marked.

There are several reasons to which the ineffectiveness of this ditch may be attributed First, the soil where the ditch was laid is a fine woody peat, well decomposed and apparently permits the water to pass through only with difficulty. It greatly contrasts with the fibrous and open peat in the Minnesota experiment. Another reason is that no thorough examination was made of the kinds of peat found in the swamp with an eye to choosing the most fibrous and open deposits, for laying the ditch through, for it is in such places that the swamp water most easily percolates into the drainage system. Possibly the most important reason, however, is that a supplemental experiment was being tried out here, by using dynamite as a cheap means of ditching through wooded swamps. The blasting made a channel about 2 feet deep, but the ragged shoulders it left and the mud-like quality of the peat has allowed the ditch to partially fill up again, greatly limiting its drainage effectiveness. It is planned, therefore, during the coming field season to improve this ditch and make certain which of these reasons may be the real cause for poor drainage.

Quadrats have been established on both swamps to follow any changes which may occur in the surface vegetation from drainage. Also a number of trees have been tagged and measured to determine their rate of growth.

4. Thinning in Norway and Jack Pine Stands

The most important management problem on the Minnesota National Forest at present is the handling of the large areas of young stands, either pure Norway pine or in mixture with jack pine. About 40 per cent of the 200,000 acres comprising the Minnesota National Forest is covered with stands of this character. This second growth Norway and jack pine ranges from stands waist-high up to pole size, about 60 feet in height.

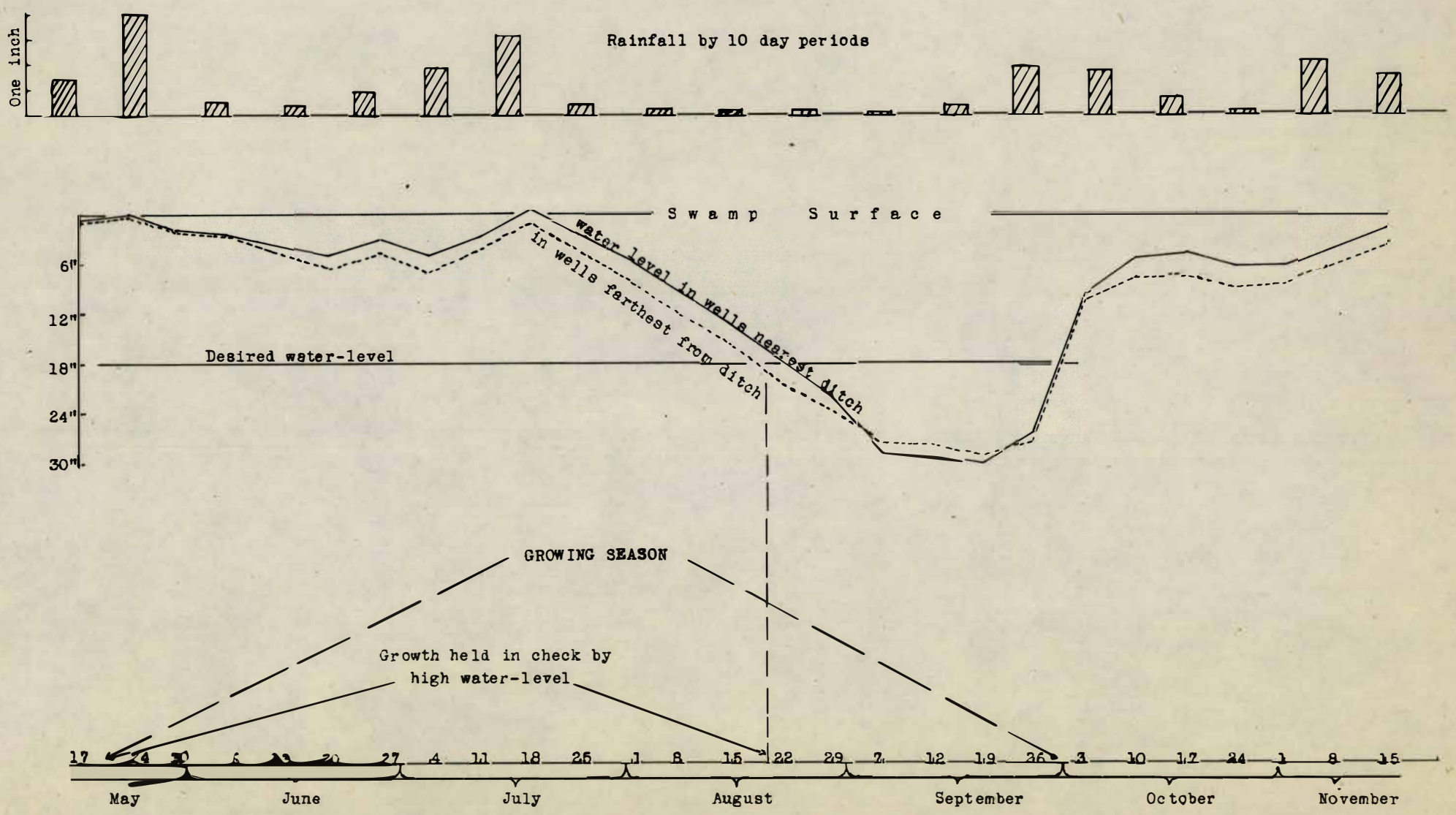
The young immature stands and the pole-size stands represent two distinct problems. The first are usually overcrowded. As a result of this, their growth is hampered and the problem arises,-- to thin out the stands in such a way that the growth of the remaining trees will be stimulated in that they may become merchantable in a shorter time than if left to fight it out among themselves. Thinnings in the immature stands can not pay for themselves at present. They are in the nature of an investment for the future.

The polewood stage of mixed Norway and jack pine is a different problem and one which promises very well for the future of the forest. The jack pine in these mixed stands, as a general rule, forms the dominant and better developed trees, since they grow in their early life faster than the Norway pine. The jack pine, being a shorter lived tree, is almost reaching its maximum of growth at from 50 to 60 years.

GRAPH II

SEASONAL TREND OF WATER-LEVEL IN A DITCHED SWAMP IN MICHIGAN

1927



The Norway pine, on the other hand, being of slower growth and a long lived tree, can continue to grow at a good rate for another 30 or 40 years. The removal of the jack pine from these mixed stands, which is a commercial timber sale, affords a splendid opportunity for harvesting jack pine at a profit and benefiting the remaining Norway pine by thinning out the stands.

Thinning of the Immature Stands: To determine the proper spacing to which trees of this age should be thinned, a series of four plots, one-tenth of an acre in size, were established in a 23-year-old Norway pine stand. If one thins out too many trees and makes the stand too open, those remaining will become bushy, like open-grown pines, and if not enough trees are taken out, those remaining soon close over the intervening space and growth once more slows down, requiring yet another thinning.

So one plot was tagged and measured to serve as a check, and the other three were thinned to approximately the following spacing, experience and observation determining the range of openness to be tried.

Range of Openness		Trees per Acre	
		Actually	
Feet	Trees per Acre	left	Removed
6x6	1210	1229	4646
8x8	680	700	3820
10x10	435	441	2993

The trees remaining were tagged and measured so that increased growth on the plots can be measured and compared.

Thinning in the Pole Wood Stage: The Station laid out four one-half-acre plots and, with the help of the administrative force on the Forest, thinned three of them. The trees on the fourth plot were left unchanged, being tagged with metal numbers and carefully measured to serve as a check on any response which thinning may bring about in the other areas.

One of the plots was marked for thinning, based on the judgment of the men on the Forest, as economically practical at this time and assuring good growth for the remaining stand--what was termed a "common sense" thinning.

The two remaining stands were marked by the men from this Station, basing their judgment on future possible practices (see Graphs III and IV). In one, the jack pine was cut out as being fully grown and also the many small Norways of about 4-inch diameter, which would eventually die out if left to be suppressed by the larger trees. Cutting of such small trees does not pay at this time, but the men on the Forest say that undoubtedly these thinnings will some day be economical. The trees left were tagged with numbers and measured, and comprise the trees which will be in the final stand when the time comes for harvesting the sawtimber.

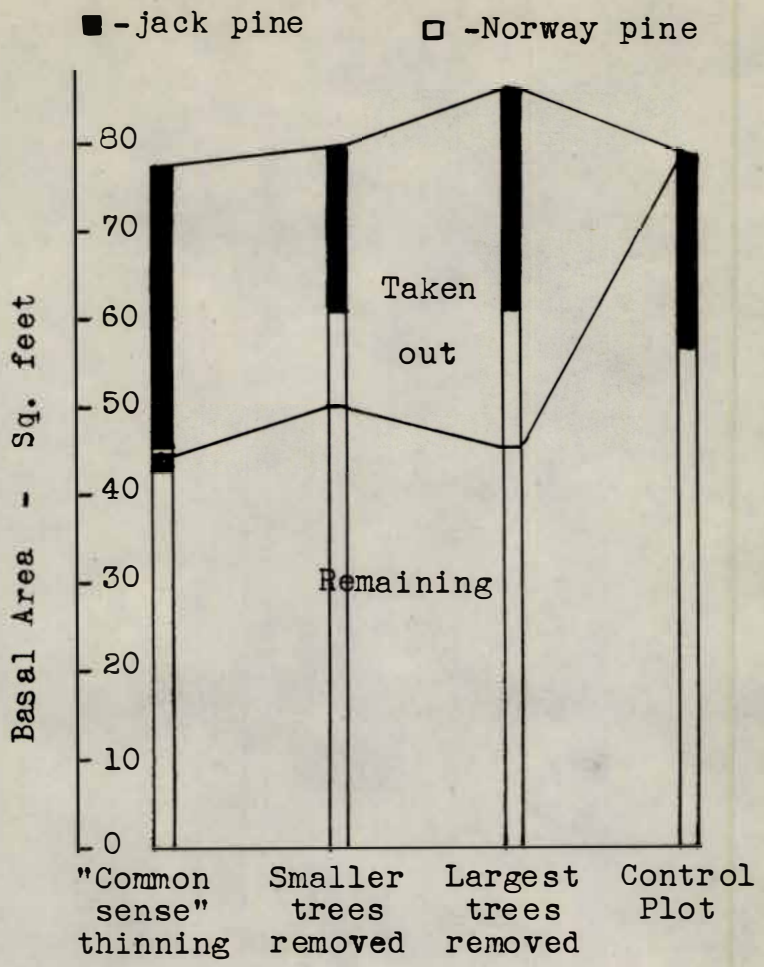
The last plot was thinned in just the opposite way; that is, all the jack pine was cut as before, but also many of the large Norways which could be taken without leaving big gaps in the stand. In this way, the trees which were saved in one case to form the final stand, are cut now as being saleable, counting on the smaller trees underneath to respond to their release from suppression and form another stand.

These pole-wood stands are now being cut. After the cutting is completed, they will be reexamined for possible injury to the tagged trees which are to be re-measured probably every five years.

Graph III

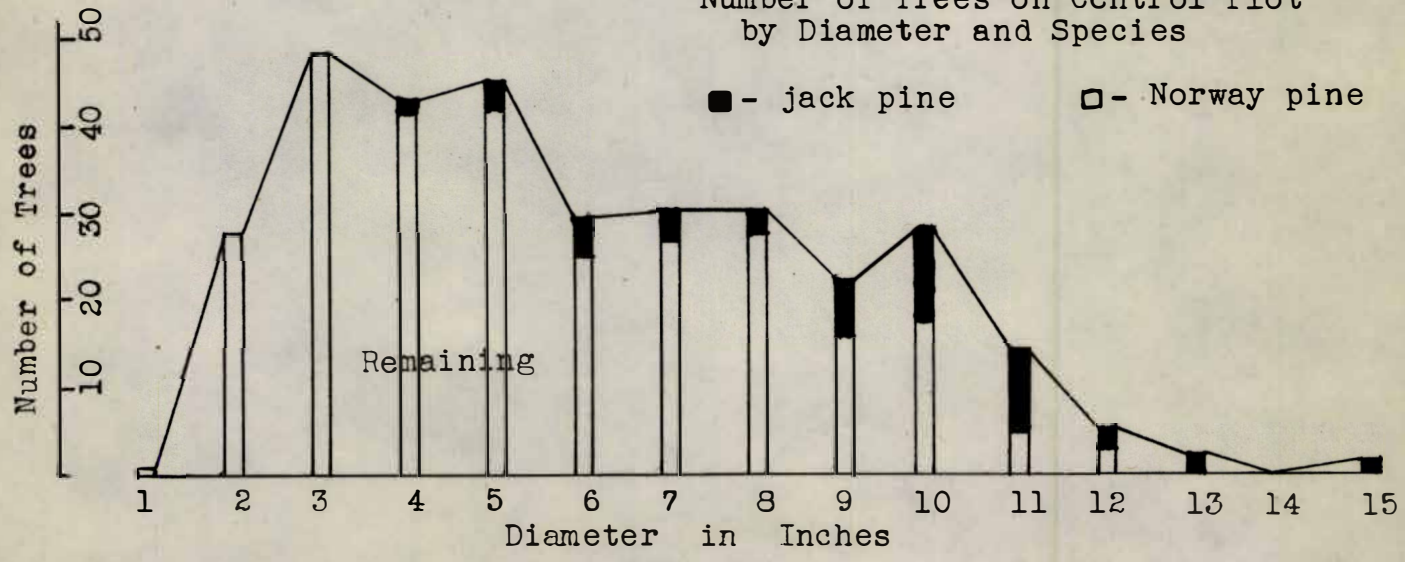
THINNING EXPERIMENT
Minnesota National Forest

Basal area comparison as to total, species, and proportion removed from each plot



Age of Stand - 53 Years

Number of Trees on Control Plot by Diameter and Species

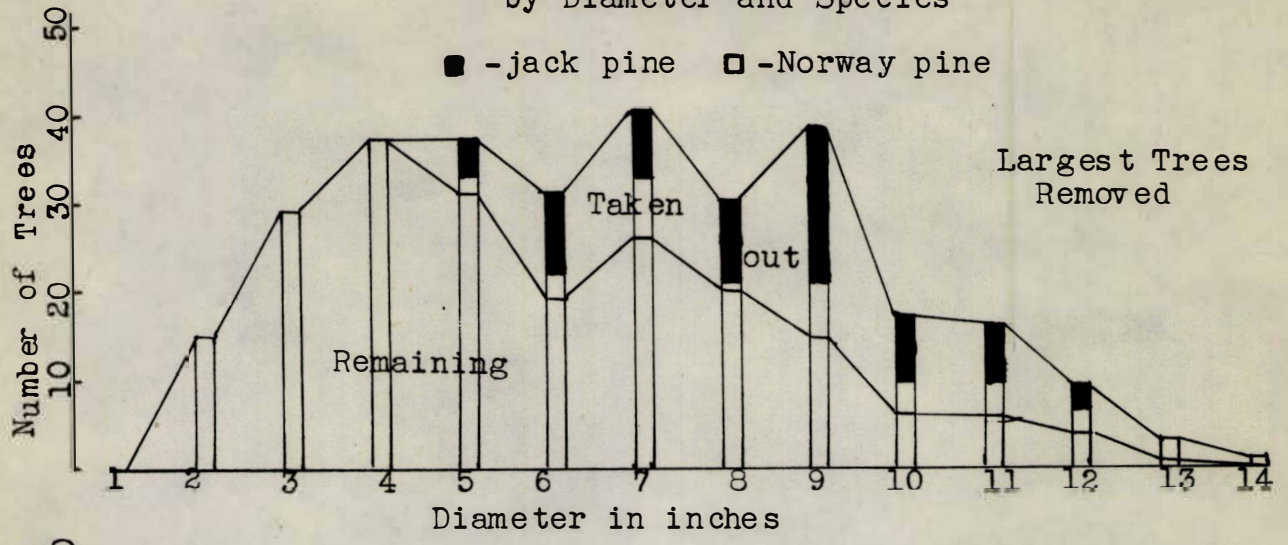


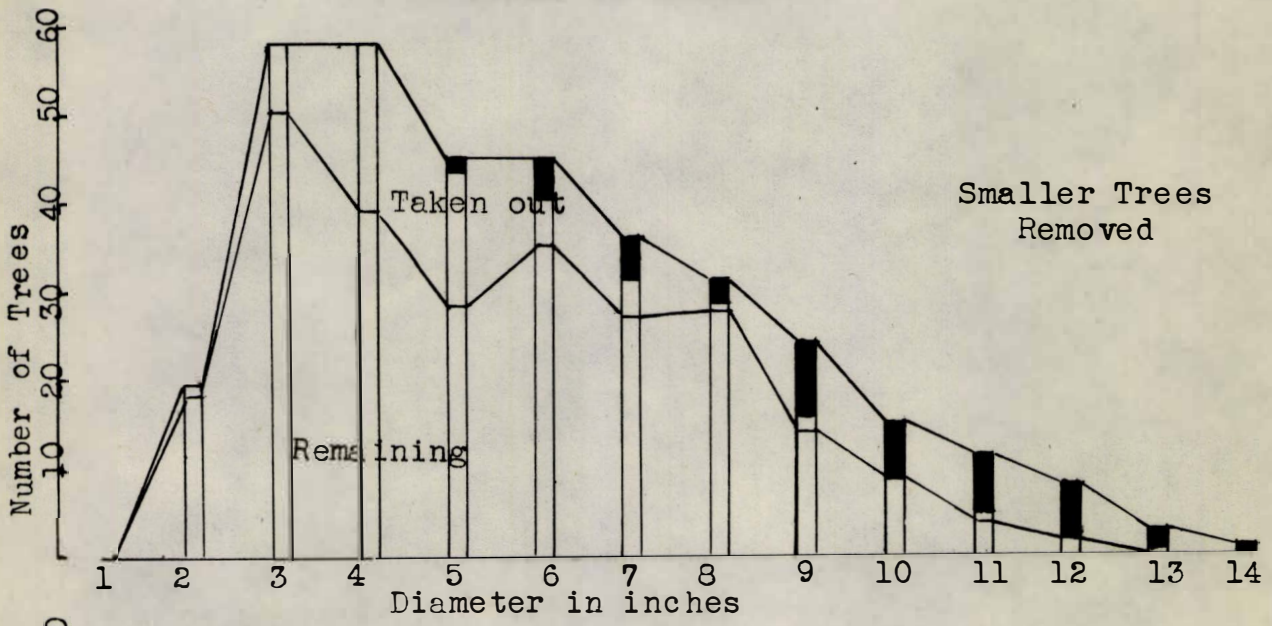
GRAPH IV

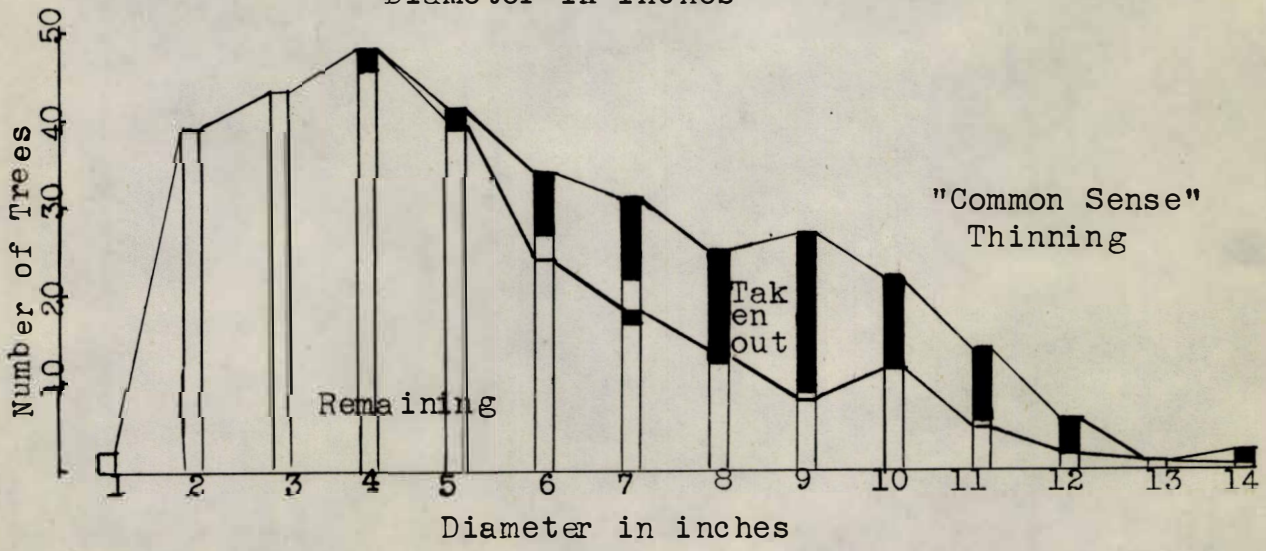
THINNING EXPERIMENT
Minnesota National Forest
Number of Trees on Thinned Plots

by Diameter and Species

■ -jack pine □ -Norway pine







5. Forest Insect Investigations

The investigation of forest insect problems in the Lake States has been conducted during the past year in cooperation with the University of Minnesota and the Bureau of Entomology, U. S. Department of Agriculture. Also the Minnesota Commissioner of Forests and Fire Prevention has been of assistance in many ways.

The problems undertaken dealt with the four most menacing forest insect groups in the region, namely: (1) the spruce budworm, (2) the jack pine sawfly, (3) the larch sawfly, and (4) the bronze birch borer.

Briefly the status of these can be summed up as follows:

1. Spruce Budworm. The activity of this defoliator on spruce and jack pine in northern Minnesota has practically ceased due to weather conditions. No further study of this insect will be made for the present.

2. Jack Pine Sawfly. A disease appeared among the larvae of this insect last year and the surviving number does not form a problem. The permanent sample plots, however, will be maintained.

3. Larch Sawfly. This insect has been in a generally quiescent state since the great outbreak of a decade or more ago when about 60 per cent of the merchantable tamarack in the Lake States was killed. The factors believed to be responsible for holding this insect in check are being studied. Mice which eat the larvae have been found to be an important factor. Conditions under larch growing on well drained soil appear to be unfavorable for sawfly winter hibernation.

4. Bronze Birch Borer. This borer attacks all species of birch. However, trees in dense stands are comparatively free from danger while those in open stands are very subject to attack. The minimum density that will prevent injury by the borer is not known, yet this is an important fact to know in the management of northern hardwoods on a sustained yield basis, particularly under the selective system.

Plans for 1928.

During the coming year the Station will devote its energies to the following five major projects: (1) management of northern hardwoods, (2) management of swamp forests, (3) fire studies, (4) reforestation studies, and (5) forest insects. Of these, only one is in the nature of a new project, namely the reforestation studies, though even this project may be considered a continuation of the old project of forest planting.

1. Management of Northern Hardwoods.

Extensive field work is planned in the experimental forests of the field station in the Upper Peninsula of Michigan. On the three experimental cuttings made last fall, covering 20 acres, permanent sample plots will be established to study the growth following different methods of cutting. Several additional areas will be cut by different methods.

To supplement the work done on the experimental forest itself, a field study is being planned in Wisconsin and elsewhere on the growth of northern hardwoods under selective cutting.

The advantages of selective logging over clear cutting in the northern hardwoods was brought out by the previous studies of the Station in a general way. There is need for more specific information as to the actual rate of growth that may be

expected under selective cutting, as compared with clear cutting, and the lapse of time between two successive cuts of various degrees. This means a field study of the actual rate of growth that has taken place in forests cut selectively and also on land cut clean. One of the difficulties in the study is that selective cutting is of very recent origin in the region, and there are not old enough areas to yield definite results. Because of the complexity of a hardwood forest, the presence of all ages and diameters, the most accurate results can be secured only through establishment of permanent sample plots cut in different ways. This is exactly what is being done at our Upper Peninsula branch station. The results of such permanent sample plots, however, will not be available for the next 15, 20, or 25 years; the longer, the more valuable the results will be.

Meanwhile, we must have some information. It is planned, therefore, to supplement the study of permanent sample plots by locating older cuttings which for one or another reason were not cut heavily. If we could get the history of the stand, the amount of timber removed in the first cutting, and then by actual survey of the present merchantable stand on the ground or, wherever a second cut has been made, of the amount removed in the second cut, we would be able to determine the rate of growth of such stands.

This, further, is to be supplemented by studies of the rate of growth of dominant trees in dense stands and in fairly open stands, in order to determine the effect of opening up the forest upon the rate of growth.

Besides the rate of growth, it is necessary to determine the mortality that occurs in the trees left on the ground between two successive cuts. Even if we know the number of trees of different diameters left on the ground and the rate at which they grow, we would still not be able to predict the amount of timber that may be found in 15 or 20 years on the area, because a number of the trees left will die. A determination of the mortality of trees of different diameters, therefore, must be an essential feature of the investigation.

For the purpose of comparing selective cutting with clear cutting, the study of the rate of growth will be extended to areas cut over clean and to a determination of the growth that takes place at present on cut-over land, irrespective of the methods by which it has been cut. A comparison of the present growth on the cut-over lands with what may be produced under selective logging ought further to show the advantages or disadvantages of selective logging over the old method of cutting.

This study will be concentrated largely in Wisconsin where it will be conducted in cooperation with the University of Wisconsin and the Wisconsin Conservation Commission.

2. Management of Swamp Forests--Effect of Water Level in Swamps upon Forest Growth

The work during the coming year will be extended to Wisconsin where in cooperation with the University, a timbered swamp will be selected and drained under controlled conditions. The swamp is to represent intermediate conditions between the one at the Experiment Station in the Upper Peninsula of Michigan and the one on the Minnesota National Forest.

In addition, a number of already drained swamps in Wisconsin, will be visited to study the effect of such drainage on timber growth.

The swamp at Ruse will be more minutely surveyed as to the topography of the bottom and composition of the peat. The present ditch will be cleaned and deepened.

3. Fire Studies

While the protection of forest land from fire has long been advocated by foresters, it is only recently that its importance has been generally conceded by the public at large. Less than a generation ago the desirability, to say nothing of the practicability, of forest fire control was viewed with skeptical indifference by the public in general, and active antagonism on the part of many forest land owners. Today the attitude of the public is one of interest and favor and many land owners are actively cooperating in the protection of their holdings. With this change in sentiment, a remarkable development of forest protective organizations both public and private has taken place. This has resulted in a demand for reliable information on which to base effective effort. Problems of organization and methods have been attacked and in a large measure solved by those actively engaged in protection work. There remains, however, a need for basic data as to the hazard, risk, and liability involved and as to the factors which influence the occurrence and spread of fires without which no entirely satisfactory plan of operation can be evolved. In recognition of this need, forest fire studies have been included as a major item in the program of the various Forest Experiment Stations. At the Lake States Station this has led to an analysis of available forest fire statistics and a study of the meteorological factors influencing the occurrence and spread of fires in the states of Minnesota, Wisconsin, and Michigan. The first of these projects, viz. the analysis of available forest fire statistics for Minnesota, has been completed and the report published. A similar report for Michigan is in the course of preparation. With this preliminary investigation out of the way the time comes to turn our attention to more fundamental aspects of the situation. Briefly, these are the conditions of cover and weather which influence the occurrence and spread of fires and the relative importance of each. The study of the weather factors has already been provided for but the study of such factors as character of cover, soil, etc., remains to be undertaken.

In a general way, it is known that cut-over areas are more subject to forest fires than virgin timber, that hardwood stands are less likely to burn than pine and large trees than small. But just how important the various factors are, or at what point or under what conditions they cease to be a menace is an open question. The need for definite information along this line as a basis for proper organization and effective action is evident. It is, however, equally important from another angle, viz., that of the investor in forest property and incidentally from the standpoint of forest insurance. In fact, when all is said and done, this phase is probably the more important since with the practice of forestry, protection becomes incidental to the management of the forest. Already protection from fire is coming to be recognized in its proper aspect - as a means to an end (the end being timber production) and not as an end in itself, a fact that, in the urge for better protection, has been well nigh lost sight of. As a matter of fact the present enthusiasm for fire protection would never have been achieved but for the growing demand for timber production and the desire of timber land owners to perpetuate their forest interests.

Recognizing the need of present and prospective investors in timber growing and of underwriters who are even now being called upon to insure growing timber, for information on which the fire hazard can be determined with reasonable accuracy, it seems logical that the Station should turn its attention to this problem. More especially is this true since the silvicultural methods followed will inevitably influence the fire hazard involved. For example, if to cut and manage timber according

to a certain plan subjects it to extreme likelihood of loss by fire while another method will insure its safety or at least minimize the risk of loss involved, only exceptional conditions will justify following the first plan though silviculturally it might be as sound as the latter. The relation of silviculture to fire hazard, therefore, cannot be overlooked.

With this in mind it is proposed to undertake as our next major fire project the study of fire hazard and its relation to weather conditions and silvicultural practice. To do this will involve a study of the inflammability of the various types common to the region, the modifying effect of weather conditions and of various methods of cutting, the hazard prevailing during different stages of the rotation involved, and how the hazardous periods can be shortened or otherwise minimized. Incidentally such a study should furnish a basis for determining the hazard involved for the information of both the investor and the insurance companies which will inevitably be called upon to underwrite such investments.

The field work for the study will be undertaken this season with the aid of the University of Wisconsin and the Wisconsin Conservation Commission.

4. Reforestation Studies

The need for further study of some of the aspects of the reforestation problem is apparent to all of us. The survey of planting operation now completed by the Station has shown that there is a minimum of 15,000,000 acres in the three Lake States which must be reforested artificially. The Station suggests a 50 year program, which would imply the planting of 100,000 acres annually in each of the three states. The present rate of reforestation in the entire Lake States is about 15,000 acres annually, or about 1/20 as rapid as proposed. Even though the needed rate should be approached only gradually, it is evident that there must be an enormous expansion of all the facilities needed to carry out such a program. It is a tremendous undertaking, which will undoubtedly sooner or later, be taken up in characteristic American fashion. Unfortunately, the results are fraught with evil and disappointment, as well as benefit, as is also true of the modest program which is being carried forward today. The fact is, we do not know what we are planting.

No less than 10,000 bushels of cones of Norway pine were collected in this region by two agencies in 1927 alone, taking advantage of one of the periodic crops of this species. If we had knowledge of all the small-scale collecting which was stimulated by the high prevailing price of Norway pine seed, we should probably find that 20,000 bushels of cones were collected, which means no less than 12,000 pounds of seed. Or, looking at it on the basis of average annual collections, the nurseries in the Lake States can be using no less than 1,000 pounds of seed annually, mostly Norway pine, while a large amount is being shipped out of the region from the unusual crops such as that of 1927. The question is, is this good seed, for use either in the Lake States or elsewhere? When one observes the methods employed by either the Forest Service or other agencies in obtaining cones, he is forced to the conclusion that much of it must be seed "without pride of ancestry or hope of posterity," for much of it will never produce commercial timber. This is true of many plantations in existence today, and in 20 years we have not changed our seed-collecting methods one iota. This is startling when one considers that we might double our care (and expense) of seed-collecting without increasing the cost of planting more than 20 cents per acre, and possibly not at all if better cones resulted in higher seed-yields and more successful nursery development, as would quite likely be the case.

To get to the point, therefore: it is evident that we dare not let the reforestation program in the Lake States develop rapidly by the present slip-shod methods as applied to seed-collecting. Every country in the world which has gone into reforestation hastily and on a large scale has learned the terrible lesson of seed source after thousands of dollars and years of effort had been wasted in fruitless planting. We do not propose to assume a destructive or even a pessimistic attitude toward an expanded planting program. On the contrary we propose to encourage reforestation by every possible means, but to begin immediately to learn of the pitfalls which must be avoided if this program is ever to be carried through to maturity, and to see that as much common sense is applied at all stages in its development as an intelligent people might be expected to exercise. We believe that a seed-control laboratory or station is needed in this region, and in this country, as much as or more than in any country of the world, both because of the enormous size of our undertaking and the wide territory from which seed of most species may be drawn. We must begin now to study the problems of seed source, from both the standpoint of geographic origin and specific parentage, and ultimately the seed-control laboratory must take up the questions involved in a still more comprehensive manner. Eventually such a laboratory must assume definite administrative functions for the protection of forest planters. This implies a study of the sources from which seeds come and a considerable knowledge of all present and possible seed-collecting activities; examination, testing by different means and identification of the sources of seeds in doubtful cases; certification as to both source and quality of seeds submitted where the evidence is sufficient to justify it

On this basis only can the planter have a guarantee that his original investment in seed or nursery stock, in planting expense, and in rental value of his land over a period of years will not prove futile or at least wholly unprofitable. And what could be more disheartening to the individual, and to the reforestation movement as a whole, than the discovery that the painstaking effort of years has produced nothing but WEEDS!

On this basis also can a legitimate and self-respecting forest tree-seed industry be built up. American seed dealers are in general in very bad repute at present because of the carelessness or culpability of a few concerns who, especially in their export trade, have permitted wholly improper stocks of seed to be supplied for certain well defined needs. Very often this is due to no other factor than that seed dealers accept seeds without question from collectors whose whole aim is the greatest quantity with the least effort. All of this must be put on an entirely different footing. Surely the use of tree seeds of quality deserves as much consideration and their production and supply will be as well rewarded as is the production and supplying of carrot seeds of quality. In the one case an error can be corrected if the result does not prove satisfactory after a few weeks of growth. In the other case twenty years may elapse before the planter of forests realizes that he has been "stung." And it is this lapse of time which "protects" the culpable dealer. The problem is wholly different from that involved in the supplying of seed or stock of trees for ornamental planting, and it is one that the industry must be encouraged to treat in a rational manner.

Specifically, it is proposed to confine activities at present to the following lines, the execution of which will give the Station ample opportunity to see the reforestation problem in its entirety and to decide what phases need further constructive effort.

(1) A study of the geographic seed sources of such important species as Norway

and white pine, from which the Lake States forests may logically and legitimately draw their seed supply, to be extended into other portions of the range of these species so far as cooperative effort will permit.

(2) A study of individual seed sources, implying the location and organizing of desirable seed sources so that they may enter into future seed-collecting; collecting and growing seeds in any amount from especially desirable sources and concentrating the different lots in two or three plantations or where not only their progeny characters may be studied, but also further selections may be made and "seed farms" developed to enter into future production.

(3) A study of the seed-storage problem for individual species. This is obviously needed for an important and largely-used species like Norway pine, which produces seed only at long intervals. It is equally important for several species which have highly perishable seed. A slightly different phase covers the problem of maturing or after-ripening of species which are slow to germinate in the seed-bed, such as white pine. This phase will not, however, be confined to the softwoods, but may be extended to certain problems of the hardwoods.

5. Forest Insect Investigations

No new work is planned and even the work under way may have to be curtailed due to shortage of funds.

Permanent Sample Plots

Although the permanent sample plots are connected with the different investigations under way, they are long time enterprises which may continue after the results of the investigations themselves have already been obtained, and so they deserve a treatment by themselves. Moreover, maintaining the permanent sample plots as a separate activity is a great convenience in planning each year's field work. With possible change in the personnel of the staff, certain permanent sample plots which were established for a particular study may be overlooked by another member of the staff who may succeed him.

The maintenance of the permanent sample plots thus becomes an activity of the entire Station and the remeasurement of the plots can fall to anyone who may happen to be in the locality where plots are in need of remeasurement. A summary of the permanent sample plots is given below.

As it may be seen, the total number of permanent sample plots so far established by the Station is thirty-seven. They cover an area of about 22⅔ acres. The largest area of sample plots is confined to the "methods of cutting in northern hardwoods." The next largest area is devoted to "methods of cutting jack pine" on the Minnesota and Superior National Forests. The rest of the sample plots are distributed among the other investigations and range from half an acre to an acre in size. This is as it should be.

With such a record of permanent sample plots constantly before our eyes, the future planning and need for permanent sample plots can be more readily gauged.

Permanent Sample Plots - January 1, 1928.

Total Number 37.

Total area 22.31 Acres.

Serial plot number	Locality	Object	Acreage	Establishment	Examination	Remeasurement
		Minnesota National Forest				
1-4	3 miles SE of Bena.	Methods of cutting Norway-white pine stands. (Mc-1)	1.47	June 20 1923	May every year	May 1931
5-8	2 miles SE of Pike Bay	Possibilities of aspen-birch lands (M-3)	0.90	May 1925	May every year	May 1931
9-12	½ mile W of Pike Bay	Methods of cutting Jack pine. (Mc-106)	4.00	May 1926	May every year	May 1932
13-17	7 miles SE of Bena.	Effect of water level in swamps upon forest growth. (M-1)	2.00	May 1927	May every year	May 1932
18-21	5 miles NW of Cutfoot Sioux R.S.	Thinning in Norway jack pine pole stands. (Mt-1)	2.00	Sept. 1927	Spring 1928	Sept. 1932
22-25	½ mile N of Cutfoot Sioux Lake	Thinning in Norway reproduction.(Mt-1)	0.54	Sept. 1927	Spring 1928	Sept. 1932
		Superior National Forest				
1-4	1 mile N of Baird R.S.	Methods of cutting jack pine. (Mc-106)	2.00	Nov. 1926	June every year	June 1932
		Ruse substation, Michigan				
1-3	1 mile W of Ruse.	Methods of cutting northern hardwoods (Mc-2)	6.00	June 1927	June every year	June 1932
4-5	2 miles W of Ruse.	Effect of water level in swamps upon forest growth (M-1)	1.90	Oct. 1927	Oct. every year	Oct. 1932
6-8	1½ miles W of Ruse.	Methods of cutting northern hardwoods (Mc-2)	1.50	Oct. 1927	Oct. every year	Oct. 1932

Cooperation

This Station, as in previous years, was fortunate in receiving active and financial cooperation from the State forest agencies in the prosecution of its investigative projects. The largest contribution, $5,350.00 came from Michigan. Wisconsin and Minnesota contributed only small amounts, $425.00 and $258.00 respectively. The College of Agriculture at the University of Wisconsin and the Wisconsin Conservation Commission, however, have just agreed upon several cooperative projects with this Station which will raise the share of Wisconsin for the coming field season by about $2,500.00.

Among the projects which are to be undertaken between this Station and the Wisconsin cooperative agencies are the following:

1. The thorough understanding of the conditions which affect the forest fire hazard within the State.
2. Growth of hardwoods and hemlock after clear cutting and selective logging.
3. The possibilities and needs of forest planting in the State.

In addition to these, several other cooperative studies will be conducted such as the value of windbreaks and the effect of moisture control in swamps on the rate of forest growth. The financing of these last two studies, although carried under the direction of the Station, will be financed entirely by the College of Agriculture of the University of Wisconsin. Similar cooperative studies are contemplated between this Station and the Michigan School of Forestry and Conservation, but final plans for such studies have not yet been made.

Demonstration and Natural Areas

The Upper Peninsula branch station, because of its strategic position extending along State Highway No. 28, is being developed as a demonstration forest area. In addition to the demonstration area, about 2 acres have been laid out to remain as natural forest area for at least 20 years, the time allotted for the removal of the timber from the demonstration forest. It is hoped at the end of the experiment that these natural areas may be retained permanently and in intact condition.

On the Minnesota National Forest, several experiments such as the methods of cutting jack pine, and thinnings in the pole-wood stage of mixed Norway and jack pine forests, will serve as demonstration areas because of their accessibility along highways. The permanent sample plots located in the experimental cuttings in jack pine are within the so-called "ten sections" of the Minnesota National Forest. These sections are to be kept intact and will, therefore, serve as natural areas. Some permanent plots will be laid out in the virgin Norway pine forests close to the present jack pine cuttings which will serve both as demonstration and natural areas.

On the Superior National Forest, there are no areas of virgin forest. This, however, does not preclude the location of these so-called "natural areas." A burn 75 years old offers just as much interest in its development as a virgin forest. The Superior National Forest is at present inactive as far as timber sales are concerned. Whatever demonstration areas are to be located there, must be in advance of actual timber sale practice. The present plans call for the withdrawal of 640 acres close to the Baird Ranger Station. This area is to be developed both as a demonstration and natural area, meaning by "natural" the old burned-over condition and not the virgin forest.

Among other natural areas, it is proposed to locate one in the "Grayling White

Pine Forest," near Grayling, lower Michigan. This is an area of 80 acres of virgin white pine purchased by the State. One of the first acts of this forest experiment station after its foundation in 1923 was to make a study of the area. This study served as a basis for further transactions by the State for the purchase of the area.

Other natural areas are desired in the hardwood-hemlock type. At present, however, there are practically no forests of this character in public ownership. We may have to wait until the proposed National Forests are established in Wisconsin and the Upper Peninsula, when an opportunity may be afforded for the segregation of a few areas into natural areas to be kept intact forever.

Phenological Observations

The Station has been carrying on observations at the Upper Peninsula branch station on the time of leafing, flowering, seed-ripening, and seed dissemination of several of the hardwood and coniferous species found on the experiment station forest. The Washington office urged the collection of such observations (phenological observations) on a very extensive basis as a distinct activity of all the Forest Experiment Stations. While such observations are undoubtedly of value, the Station questions that concrete results can be obtained unless such observations are organized as an individual project and not merely carried as an activity.

Phenological observations have long been recognized and used as an exercise in the general observation of natural phenomena. We question, however, whether much of a concrete nature has ever come from such observations. They have been, and probably always will be, merely academically interesting unless undertaken with some definite purpose, as, for example, with the object of correlating different stages of growth, flowering, and fruit formation, with complete meteorological observations. For this reason we can see no object in making general phenological observations except at a few of our permanent stations where there is available a complete weather record; including observations of soil temperature and moisture.

Take the matter of seed-production, which is of much more than academic interest. There is no doubt but that in many cases the production or non-production of a seed crop is dependent on certain weather phenomena occurring about the time of flowering. Phenological observations alone may tell us that flowers form, and later have either developed into fruits or have withered and disappeared. We are not, then, one bit wiser than we were before. But if the occurrence of withering can be correlated, at the time, and by means of daily observation, with certain phenomena such as frost or cold rain, then we have established a measuring stick of the probabilities of seed production, in terms of weather probabilities.

We do not need and can not use a great mass of unclassified phenological observations. On the other hand, if the whole country could be covered by observations on a few of the most important species, in such a manner that the several ranges would be overlapping and could be correlated one with another, and if in each particular locality there could be had complete weather records actually applicable to woods conditions or to the conditions where the growth phenomena were observed, then we might hope to have eventually a growth map of the country involving all of the more important climatic factors. But we do not believe this effort would be justified unless someone is prepared to organize it and carry it through very studiously. There may be four or five places in the Lake States, where such observations could be obtained without new installations.

Publications

Bulletins and Articles Prepared during 1927.

Raphael Zon	Forests as a Factor in Flood Control within the Upper Mississippi Basin. (Unpublished manuscript)
	The Problem of the Pulpwood Supply in the Lake States. Paper Trade Journal, February 24, 1927.
	Do Forests Prevent Floods? American Forests and Forest Life. July, 1927.
	Taming the Father of Waters. Journal of Forestry, May, 1927.
	Reforestation--A Practical Method of Flood Control. Floods, Forests and the Future. American Tree Association, August, 1927.
	Our Forest Schools. Journal of Forestry. March, 1927.
	Improving Timber Growth in Northern Swamps. (Prepared for U.S. Department of Agriculture Yearbook, 1927)
	New Logging Methods for Old. (Prepared for U. S. Department of Agriculture Yearbook, 1927)
	Silviculture as a Factor in Maintaining the Fertility of Forest Soils. (Unpublished manuscript)
	Forest Conditions in Wisconsin. Proceedings of Wisconsin Commercial Forestry Conference.
	Timber Growing and Logging Practice in the Lake States. U. S. Department of Agriculture Bulletin 1496.

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Raphael Zon	Forests and Forestry. Article of 12,000 words for Encyclopaedia Brittanica - new edition.
Zon and J. L. Averell	Drainage Problems in Relation to Forest Growth.
	Forest Leaf Litter--Its Biological Significance and Fertilizing Value.
J. Kittredge, Jr.	Forest Planting in the Lake States. (Bulletin)
	Possibilities of Aspen Lands in the Lake States. (Bulletin)
	The "Scrub" Oak Lands of Michigan. (Bulletin)
	Some New Forest Statistics of Michigan. (Article)
	The Use of Soil Surveys in Forestry. (Article)

J. A. Mitchell

Forest Fires in Michigan. (Bulletin)

Fire Hazard as Affected by Weather Conditions and the Character and Condition of the Forest Cover. (Article)

Precipitation Probabilities in the Lake States as a Criterion of Fire Hazard. (Article)

Allotments and Expenditures

The allotments for the Lake States Experiment Station for the last three years are as follows:

1925	$33,289.67
1926	27,207.34
1927	27,320.26

Distribution of Funds by States

How the investigative funds were spent by States, for the last three years, is given below:

	1925	1926	1927
Michigan	$ 7,425.20 27.3%	$ 9,549.14 36.3%	$ 9,944.57 36.4%
Minnesota	12,434.19 45.7	13,034.75 49.5	11,037.39 40.4
Wisconsin	7.347.95 27.0	3.753.73 14.2	6,338.30 23.2
	$27,207.34 100%	$26,337.62 100%	$27,320.26 100%

Expenditures for 1927 Including State Cooperating Agencies.

	Funds of the Station	Cooperation	Total
Michigan	$ 9,944.57 36.4%	$ 5,350.00 88.7%	$15,294.57 45.8%
Minnesota	11,037.39 40.4	258.20 4.3	11,295.59 33.9
Wisconsin	6,338.30 23.2	425.00 7.0	6,763.30 20.3
	$27,320.26 100%	$ 6,033.20 100%	$33,353.46 100%

Distribution of Funds by Lines of Work

The distribution of the funds of the Station by lines of work for the last three years is shown in the following table:

	1925		1926		1927	
Fire	$6,617.17	24.3%	$4,431.97	16.8%	$3,682.53	13.5%
Forestation	3,391.00	12.5	2,935.64	11.1	912.27	3.3
Influences	69.37	0.3	1,071.07	4.1	4,314.76	15.8
Management	9,832.65	36.1	13,191.01	50.1	13,064.24	47.8
Measure-ments	3,806.66	14.0	1,744.87	6.6	841.62	3.1
Protection other than fire	13.39	--	288.89	1.1	52.99	0.2
Tree Studies	---	--	125.63	0.5	28.16	0.1
Type Studies	1,102.85	4.1	528.99	2.0	951.42	3.5
Special Studies	2,374.25	8.7	2,019.55	7.7	3,472.27	12.7
	$27,207.34	100%	$26,337.62	100%	$27,320.26	100%

Lake States Forest Experiment Station, St. Paul, Minnesota.
(Station established 1923)

Raphael Zon	Director
C. G. Bates	Silviculturist
Joseph Kittredge, Jr.	Silviculturist
J. A. Mitchell	Silviculturist
A. E. Wackerman	Junior Forester
(resigned April 9, 1927)	
J. L. Averell	Junior Forester
E. L. Mowat	Junior Forester
S. A. Graham	Forest Entomologist
Mary A. Norton	Senior Clerk
Evelyn J. Peck	Junior Clerk

Temporary Field Assistants During 1926

W. W. Chase — F. G. Whitney
L. M. Wood — I. H. Taylor
S. R. Gevorkiantz

Collaborators, 1926

Dr. Henry Schmitz — T. S. Hansen

Collaborating Agencies

Michigan State College of Agriculture
University of Michigan
University of Minnesota
University of Wisconsin
University of Chicago
Northern Hemlock and Hardwood Manufacturers Association
Upper Peninsula Development Bureau
Department of Conservation of Michigan
Department of Conservation of Minnesota
State Conservation Commission of Wisconsin
Bureau of Public Roads
Forest Products Laboratory
Cleveland-Cliffs Iron Company
Michigan National Forest
Minnesota National Forest
Superior National Forest